Hortense Hot Springs. The waters issue from rocks of various compositions, ranging in age from Precambrian to Tertiary.

Sixteen surface or near-surface measurements of flow of heat from the interior of the earth have been made in Colorado and published. These measurements range from a low of 1.4 H.F.U. (heat flow units) at Yellow Creek in the northwest part of the state to a high of 3.7 H.F.U. at Ouray, Colorado, in the San Juan Mountains.

It appears, from interpreting published data, that the San Juan volcanic region of southwestern Colorado has the most potential for the development of a commercial geothermal reservoir.

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EPIGENETIC ALUNITE PISOLITES FORMED BY NATURAL GASES IN WESTERN MERCED COUNTY, CALIFORNIA

Chemical and mineralogic processes related to the migration of natural gases are of importance for petroleum geology. An unusual alteration of sedimentary formations by hydrogen sulfide-bearing natural gases in western Merced County, California, has been described. The alteration created an acidic medium (with pH values ranging from 0.5 to 4.5) containing sulfur, sulfides, sulfates, and black and white discoloration.

A peculiar layer of pisolitic sandstone was noted in the altered area near the boat-launching ramp on the southeastern shore of the O'Neill Reservoir. Individual pisolites 2-15 mm in diameter are present as an undulatory layer in a bed of light-gray, fluvial sandstone of the Tulare Formation, below the Pleistocene Corcoran Clay Member. X-ray diffraction of the sandstone cement yielded abundant alunite.

Data collected during studies of iron sulfide concretions from the same locality yielded some information on origin of pisolites. An aluminum sulfate-bearing gel was repeatedly obtained by solution of concretions in concentrated nitric acid. Aluminum was produced by decomposition of alumosilicates with sulfuric acid derived from oxidation of sulfides cement.

Alunite pisolites probably originated by decomposition of alumosilicates occurring in sandstone by reaction with sulfuric acid created by oxidation of hydrogen and/or iron sulfides in excavations. Natural gases in the area, following joints, tend to cause dome-shaped uplifts in overburden, which explains the undulatory occurrence of pisolitic layers. Their position could be controlled by a capillary uplift.

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LATE MISSISSIPPIAN CYCLOTHEMS OF HEATH FORMATION, WESTERN NORTH DAKOTA

On the south flank of the Williston basin in western North Dakota, the Heath Formation (Chester) produces from several fields including Rocky Ridge field. In 1969 Shell Oil Company discovered additional Heath production several miles southeast of Rocky Ridge. Cores cut during this drilling program provided the basic data for this study.

Lithologies represented in the cores run the complete spectrum of sandstone, siltstone, shale, limestone, dolomite, coal, and even subaerial, lateritic soils and subaquaeous, underclay soils. Mechanical log correlations create the impression of erratic depositional patterns typical of alluvial deposits. Faunal data, however, indicate oscillating brackish to shallow-marine depositional environments, the several coals and underclays indicate periods of marsh conditions, the crossbedded, conglomeratic sands are interpreted as fluvial to estuarine, and the lateritic soils are indicative of subaerial exposure. Such sequences or rock types are typical of the cyclothems of Illinois and Kansas.

At least 3 cyclothems are represented in the Heath. The initial basal transgressive sands were deposited above or at sea level in the topographic lows eroded during the preceding regression. As sea level rose, depositional environments covered a progressively greater area, depending on the amount of topographic relief. Consequently, an underclay lying on a previously formed lateritic soil may represent the basal unit of the cycle. In areas of greatest relief only the deposits of maximum transgression are represented. The complete succession of members of the classical cyclothem is present in very few places.

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SEDIMENTARY LAYER PROPERTIES OF GRADED-SHELF DEPOSITS, COLORADO GROUP (CRETACEOUS), SASKATCHEWAN

Middle Albian to Santonian detrital sediments were deposited in a shallow sea east of the Rocky Mountain geosyncline. Two transgressive phases of dominant mud deposition were separated by a major regressive phase, represented by a northeastward-thinning wedge incorporating conglomerate and sandstone.

The transgressive Joli Fou Formation is represented on the east by the Spinney Hill Sandstone, comprising cosets of planar sandy foresets and subordinate mudstone intercalations (proximal fluviomarine deposits). These grade westward into a succession of vertically repeated, sandy, fining-upward sequences (distal fluviomarine deposits) overlain by and passing laterally into mudstone. The fining-upward sequences comprise, in ascending order, planar sandy foresets, bioturbated sandstone, alternating sandstone and mudstone, and mudstone. The sequence probably reflects lateral migration of the tidal channels of an estuarine delta.

The regressive Viking Formation gave rise to deposits in which size fractionation through increase in the proportion of admixed mud northeastward is accompanied by progressive change in assemblages of sedimentary structures. A thick sequence of planar sandy foresets and subordinate mudstone intercalations (nearshore deposits) is replaced by clinobeds composed of coarsening-upward sequences (proximal shelf deposits), which northeastward grade to bioturbated, muddy sandstone (distal shelf deposits) and mudstone (shelf muds). The Flatten Lake sand displaying southwestward diminution of grain size along the erosional edge of the Colorado succession is referable to the regressive phase.

The pre-Cenomanian (Big River Formation) of the late transgressive phase is predominantly mudstone, replaced northeastward by fine-grained, horizontally laminated and micro-crosslaminated sandstone and bioturbated sandstone, with abundant discontinuous mudstone intercalations (St. Walburg Sandstone). These beds are succeeded by a thick mudstone incorporating northeastward-thinning units rich in bioclastic debris: a basal unit rich in fish remains (fish-scale marker) and 2 main calcareous units containing coccolith aggregates and pelecypod debris (Greenhorn and Niobrara equivalents). The bioclastic debris commonly is in thin, graded layers passing upward into mudstone. Lateral size fractionation within the units occurs by progressive decrease in proportion of sand and silt and concomitant increase in mud content.

The principal agents of sediment transportation recognized are tidal currents occasionally augmented by storm-surge waves giving rise to both laterally migrating channels and large-scale sand ridges. Mass movement of sand downslope apparently was confined to local salt-solution sinks.

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UTAH'S OIL-IMPREGNATED SANDSTONE DEPOSITS—A GIANT UNDEVELOPED RESOURCE

Fifty deposits or groups of deposits of oil-impregnated sandstone (tar sand) in Utah contain between 20 and 25 billion bbl of oil, about 95 % of the nation's resource. The Uinta basin, northeast Utah, is ringed by 25 deposits, estimated to contain 10.5 to 11.0 billion bbl of oil in place, with about 95 % in 4 giant

deposits: Asphalt Ridge, Hill Creek, PR Springs, and Sunnyside. In central-southeast Utah, 21 deposits contain between 10 and 15 billion bbl, a less precise estimate because of the lack of definitive subsurface data. About 90 % of this is contained in 3 giant deposits. Elsewhere in Utah 4 less important deposits are found.

A wide variety of crude oils in varying stages of preservation and alteration has been analyzed. Gravities (API) range from minus values to near 15°; range in deposits considered of commercial interest is 8 to 15°. Uinta basin deposits of Tertiary age contain oil with an average sulfur content around 0.4 %. Permian and Triassic deposits in central-southeast Utah yield oils with between 3.0 and 4.3 sulfur.

Two types of deposits are recognized: *in situ* (oil fields in their original position breached by erosion) and migrated (oil displaced from a ruptured trap to another position). Most southern Uinta basin and central-southeast Utah deposits are *in situ;* northern Uinta basin deposits appear to be migrated; actually they are seeps disseminated on the outcrop.

The deposits exist in a wide variety of physical situations, and reservoirs tend to be heterogeneous. Mining appears to be the most likely method of large-scale exploitation. Serious legal, political, environmental, and technologic problems exist. Growing scarcity of energy and petrochemical sources is creating an economic climate in which development is feasible.

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CHARACTER DISPLACEMENT IN CAMBRIAN AGNOSTID TRILOBITES

The phenomenon known as *character displacement* develops when the ranges of 2 or more closely related species overlap geographically. Differences between the species are accentuated in the zone of sympatry, but remain less pronounced in the parts of their ranges outside that zone. Characters displaced may be morphologic, ecologic, behavioral, or physiologic. Biologists have shown that size is one of the most common morphologic characters displaced. A moderate difference in size—on the order of 1.3—appears to be sufficient to cause obligated feeding on different kinds of food, and thus permits sympatric species to avoid competitive elimination.

Although character displacement in modern faunas has been well documented, to my knowledge no examples have been described from the fossil record. Analysis of several extensive collections of Cambrian fossils suggests that size displacement was common among agnostid trilobites. Where 2 or more agnostid trilobites are found together, the interspecific ratio of maximum size usually is close to 1.3. Also, maximum size generally is more uniform where given species are separated than where they are found together. The similarity of these patterns to those displayed by certain modern faunas indicates that sympatric agnostids were structurally specialized to feed on resources of different sizes. This conclusion helps to explain how superficially similar species of Cambrian agnostids may have coexisted without competitive elimination. The examples further indicate that character displacement was operating early in the history of metazoans.

SPEARING, D. R., G. K. GUENNEL, Marathon Oil Co., Denver Research Center, Littleton, Colo., and J. A. DORR, JR., Dept. Geol. and Mineralog., Univ. Mich., Ann Arbor, Mich.

LATE CRETACEOUS AND EARLY TERTIARY STRATIGRAPHY AND PALYNOLOGY, HOBACK RIVER BASIN, WESTERN WYOMING

Pollen samples collected in the Hoback River basin yield Eocene, Paleocene, and Late Cretaceous dates. These dates, especially the Late Cretaceous ones, have helped redefine the stratigraphy in this area. Previously mapped Paleocene parts of the Hoback Formation can now be assigned to Upper Cretaceous Harebell Formation, Mesaverde Formation, and lenticular sandstone and shale sequence.

The pollen data also confirm structural reinterpretations. Previous maps show an anticlinal fold in the Hoback Formation, which parallels the Cliff Creek thrust. The Game Hill fault has been mapped, and places Cretaceous rocks against a middle Paleocene slice of the Hoback Formation. This slice lies between the Cliff Creek thrust and Game Hill fault. Evidence suggests the Game Hill fault predates the Cliff Creek thrust.

In addition to aiding structural and stratigraphic refinements in this area, the pollen samples allow comparison between early Tertiary invertebrate, vertebrate, and palynologic dates derived from identical sites.

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FOSSILIFEROUS CONCRETIONS—POSSIBLE EVIDENCE OF PURPOSEFUL FOOD GATHERING

Concretions containing many, closely packed fossils are sufficiently numerous to warrant special attention and probably a distinctive designation. A few examples emphasize the problem of origin: (a) one concretion from shale above the no. 5 coal bed of Illinois (Pennsylvanian) yielded at least 1,000 uncrushed *Composita argentea;* the sparse fauna of the matrix is extensively crushed; (b) 3 concretions from the Deseret Limestone (Mississippian) of north-central Utah yielded several hundred specimens of the ammonoid *Dzhaprakoceras* known previously only from Asia; (c) one concretion from the Colorado shale (Early Cretaceous) near Harlowton, Montana, yielded 1,400 uncrushed specimens of the ammonite *Gastroplites,* a relatively rare genus in North America, (d) numerous concretions from the Ferron Sandstone (early Late Cretaceous), Emery County, Utah, under investigation by the writers, have a well-preserved molluscan fauna, whereas the matrix is practically unfossiliferous; and (e) very abundant concretions in the Fox Hills Formation (late Late Cretaceous) of South Dakota commonly show dense accumulations of several molluscan species; fossils are otherwise sparse.

It is proposed that such fossiliferous concretions have resulted from selective, purposeful, food-gathering or hoarding activities of large vertebrate or invertebrate marine animals. No other agency seems capable of bringing together large numbers of sessile, somewhat heavy, and probably still-living animals into small compact masses. Whether these represent food not yet ingested, undigestable residues (coprolites?), or contents of some part of the alimentary canal in process of digestion is not known. The term "gastric concretion" is proposed as sufficiently broad and descriptive to cover this type of accumulation.

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GEOLOGICAL MALPRACTICE, AN APPROACHING THREAT

Geologists' studies of environment of deposition are increasingly subject to scrutiny by those who are not professionally knowledgeable in the subject. The study becomes one related to the phrase "to depose" and the environment becomes the legal context of malpractice litigation, the scrutiny by lawyers. Until very recent years, professional earth scientists were well insu-